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Simulation of Shunt Active Filter

Patel Pratikkumar T, P. L. Kamani, A.L.Vaghamshi

***Abstract*— Active filtering of electric power has now become a mature technology for harmonic and reactive power compensation in three phase three-wire and three phase four-wire ac power networks with nonlinear loads. Shunt active filter provides equal and opposite current to harmonic current produced by load into line. The objective of this paper is to obtain effective compensation of harmonic currents present in source due to nonlinear load and also compensation of reactive power using shunt active filter for sinusoidal and distorted supply voltage. Simulation of shunt active filter for three phase three wire networks using generalized fryze strategy gives to guarantee linearity between the supply voltage and the compensated current. Fryze strategy also gives reduction in calculations compare to pq strategy. Hysteresis current control technique is effective technique for simulation of shunt active filter. Simulation results using matlab/simulink shows that shunt active filter gives effectively compensation of harmonic currents due to non linear load and reactive power by reducing Total Harmonic Distortion (THD) in source current. The simulation results confirm the improvement of the quality of energy, by maintaining the THD of the source current after compensation well below 5%, the harmonics limit imposed by the IEEE-519 standard.**

***Index Terms*—Shunt active filter, Fryze technique, Harmonic compensation, Reactive power compensation.**

I. INTRODUCTION

At present harmonic compensation is very important concern in industry. Harmonic filters are available as Active filter and Passive filter. An active harmonic filter is something like a boost regulator. The concept used in an active filter is the introduction of current components using power electronics to remove the harmonic distortions produced by the non-linear load. Active harmonic filters are mostly used for low voltage networks [1].

II. SHUNT ACTIVE FILTER

Figure 1 shows basic configuration of a shunt active filter for harmonic current compensation of a specific load. Shunt active filter inject harmonic current equal and opposite in phase to harmonic current produced by load into line.

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Patel Pratikkumar T., M.E. Scholar, Electrical Engineering Department, Government engineering college, Bhuj, India.
Mo. 9712260060
P. L. Kamani, Associate professor, Electrical Engineering Department, Government engineering college, Bhuj, India.
A.L.Vaghamshi, Assistant professor, Electrical Engineering Department, Government engineering college, Bhuj, India.

There are mainly three current control strategies available for shunt active filter.

- Constant instantaneous power control strategy
- Sinusoidal current control strategy
- Generalized Fryze current control strategy

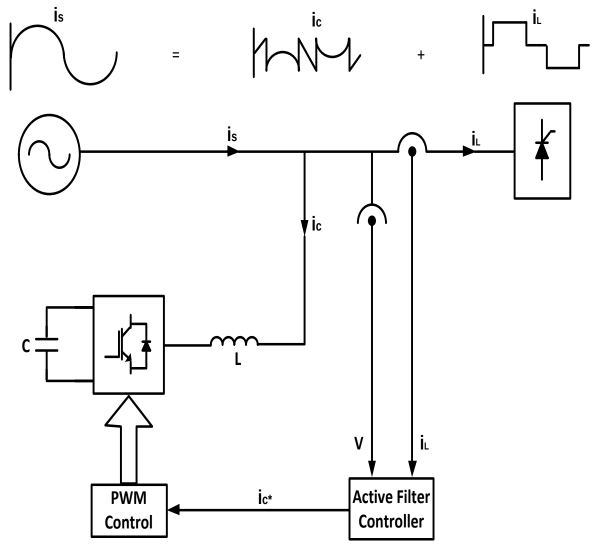

Figure 1. Basic configuration of shunt active filter

III. FRYZE STRATEGY

Figure 2 shows the complete control circuit for a real implementation of the generalized Fryze current control strategy. An advantage of the generalized Fryze current control strategy is the reduced calculation effort, since it works directly with the *abc*-phase voltages and line currents. The elimination of the Clarke transformation makes this control strategy simple compared to PQ strategy.

The instantaneous equivalent conductance G_e is calcul
The instantaneous equivalent conductance G_e is calculated from the three-phase instantaneous active power, and the squared instantaneous aggregated voltage. The average conductance $\overline{G_e}$ is obtained, passing G_e through a low-pass filter. The instantaneous active portions $i_{\overline{wa}}$, $i_{\overline{wb}}$ and $i_{\overline{wc}}$ of the load current are directly obtained by multiplying $\overline{G_e}$ by the phase voltages V_a, V_b, and V_c, respectively. Then compensating current obtained by subtracting load current from active current [2].

So compare to other techniques Fryze technique is easy to understand and also easy in calculation.

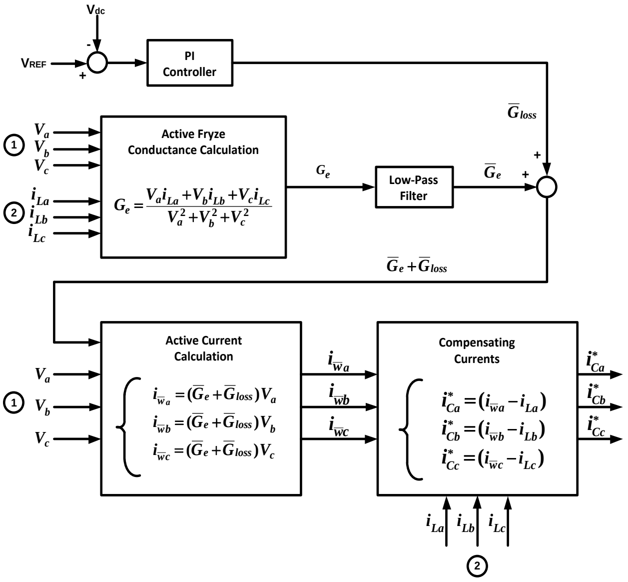

Figure 2.Real Implementation of the Generalized Fryze Currents Compensation

A positive-sequence voltage detector in terms of "minimized voltages" is developed. A dual principle for voltage minimization is employed, together with a phase-locked- loop circuit (PLL circuit). In fact, this dual principle of voltage minimization is used here for extracting "instantaneously" the fundamental positive sequence component from a generic three phase voltage.

The distorted and unbalanced voltages of the power supply are measured and given as inputs to the PLL circuit. It determines the signals i_{al}, i_{bl} and i_{cl} which are in phase with the fundamental positive-sequence component. Thus, only the magnitude of positive-sequence voltage is missing. The fundamental characteristic of the used PLL allows the use of a dual expression for determining active voltages.

Therefore, it is possible to guarantee that the signals V_{al}, V_{bl}, and V_{cl} are sinusoidal and have the same magnitude and phase angle of the fundamental positive-sequence component of the measured system voltage.

So by using positive sequence voltages, we can obtain guaranteed sinusoidal supply current even if supply voltage contains harmonics.

IV. Hysteresis Current Control Technique

The principles of hysteresis band current control can be seen in figure 3. The difference between the reference value and the actual value will be directed to one comparator with a tolerance band. The controller generates the sinusoidal reference current of desired magnitude and frequency that is compared with the actual motor line current. If the current exceeds the upper limit of the hysteresis band, the upper switch of the inverter arm is turned off and the lower switch is turned on. As a result, the current starts to decay. If the current crosses the lower limit of the hysteresis band, the lower switch of the inverter arm is turned off and the upper switch is turned on. As a result, the current gets back into the hysteresis band. Hence, the actual current is forced to track the reference current within the hysteresis band as shown in figure [3].

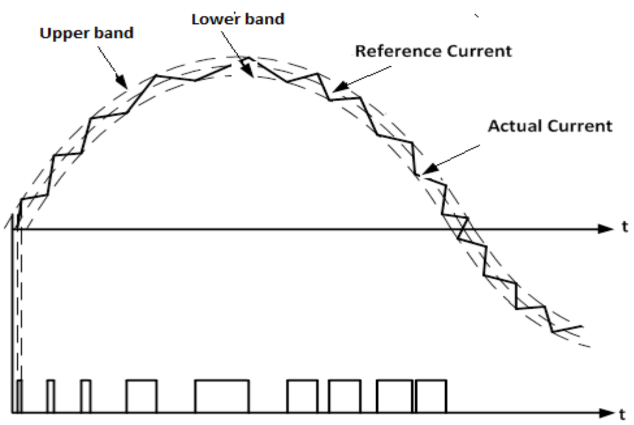

Figure 3.Hysteresis current control technique

V. The Positive Sequence Voltage Detector

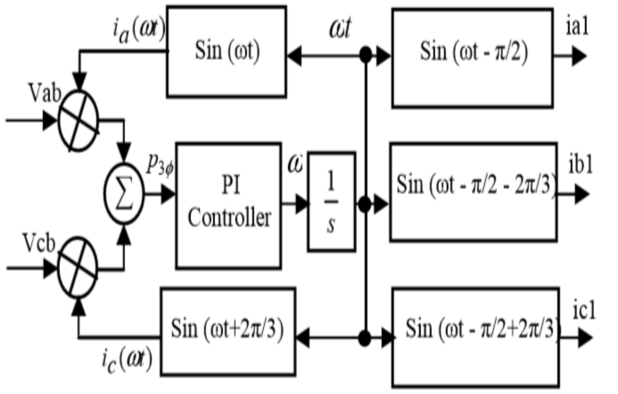

Figure 4 (a).PLL Circuit

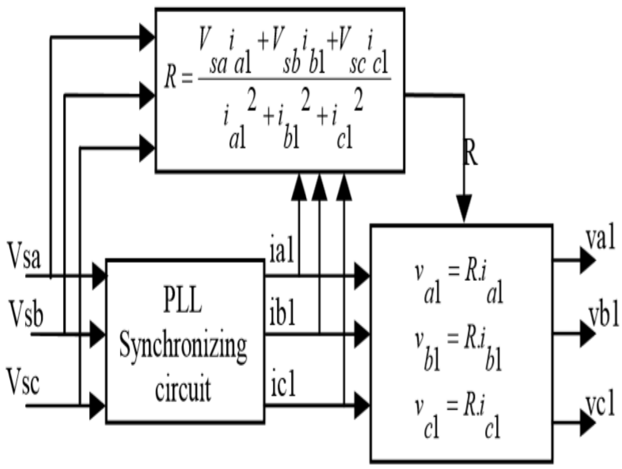

Figure 4(b).Positive sequence voltage detector

VI. Simulation And Result Analysis

Simulation of shunt active filter was carried out for compensation of harmonics and reactive power using matlab/simulink. It also improve power factor. Simulation Data are as below.

Parameter	Value
Supply Frequency	f = 50Hz
Source Voltage	V = 230V
Switching Frequency	fs = 10KHz
Source Resistance and Inductance	Rs = 1ohm and Ls = 0.5 mH
Filter Resistance and Inductance	R_f = 1ohm and L_f = 2.35 mH
Load Resistance and Inductance	R_L= 20 ohm and L_L = 100 mH
Dc link Capacitor	C = 1100 µF
Dc link voltage	Vc = 600 V

Simulation results are obtained for both sinusoidal supply voltage and also for distorted supply voltage. Here 5% of fifth harmonic and 3% of seventh harmonic are added in supply voltage. Simulation results are as below.

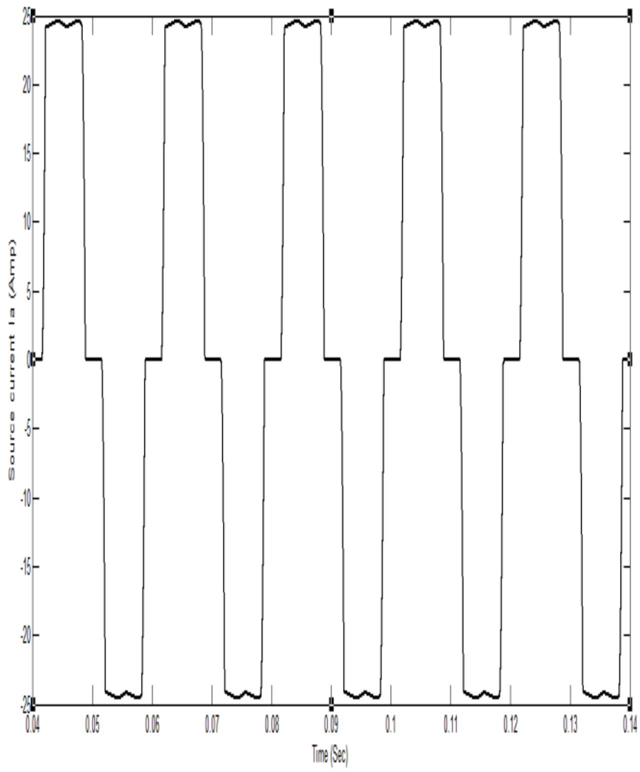

Figure 5(a). Source current (Phase A) without Compensation

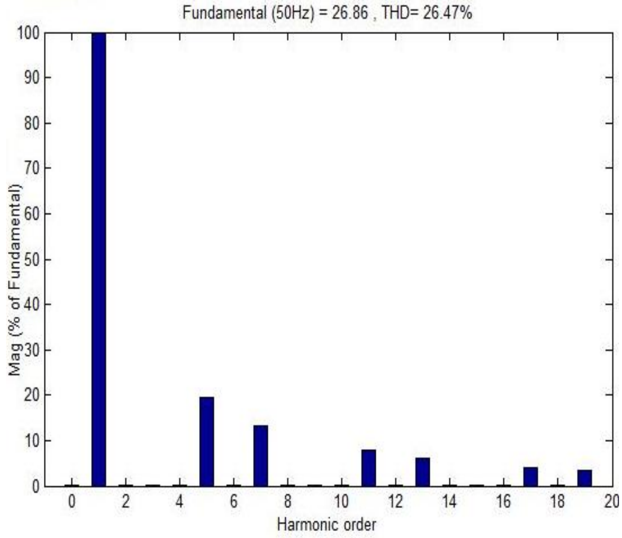

Figure 5(b). THD of Source current without compensation

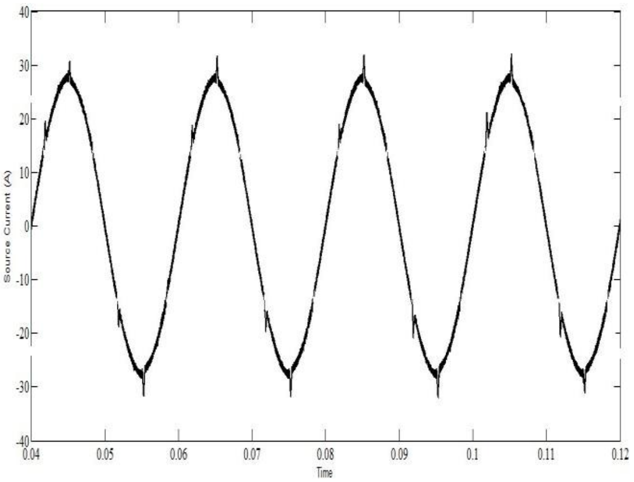

Figure 6(a). Source current after compensation

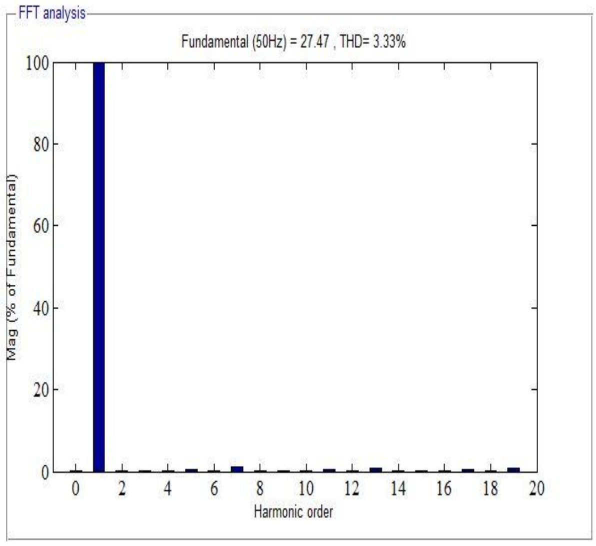

Figure 6(b). THD of source current after compensation

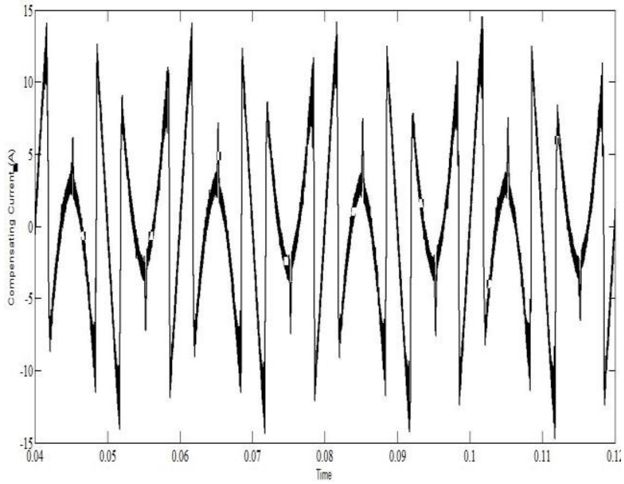

Figure 7. Compensating current of phase a drawn by shunt active filter

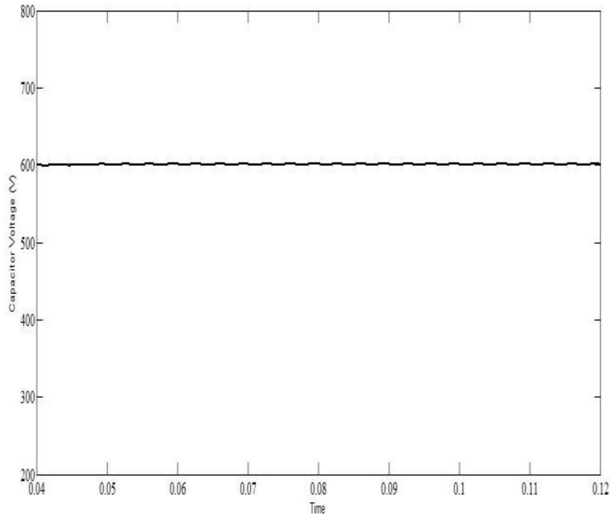

Figure 8. Capacitor voltage of shunt active filter

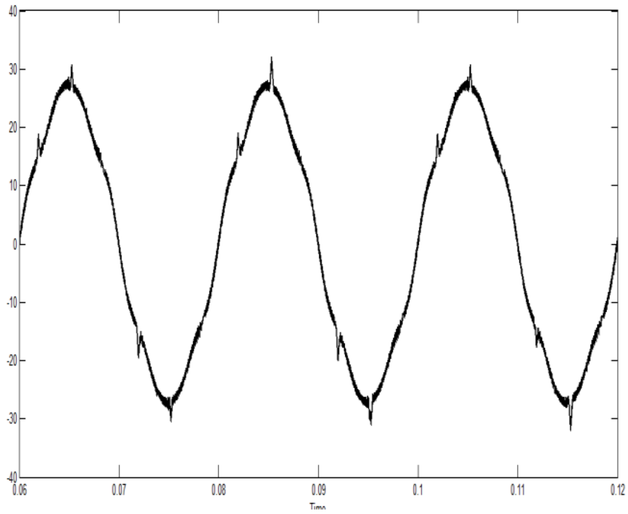

Figure 9(a). Source current for distorted supply voltage without Positive sequence detector.

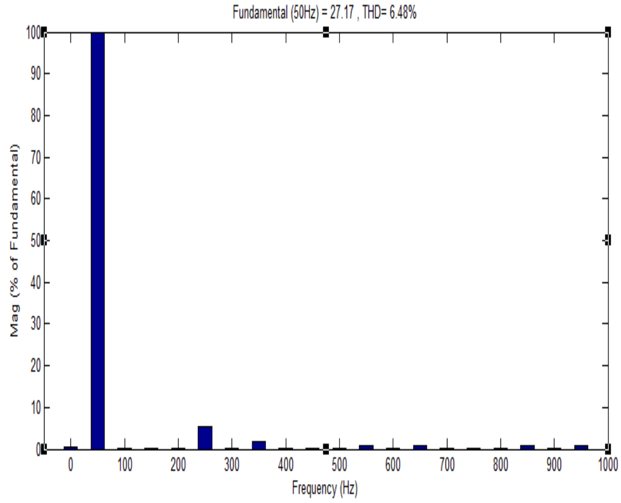

Figure 9(b). THD of Source current

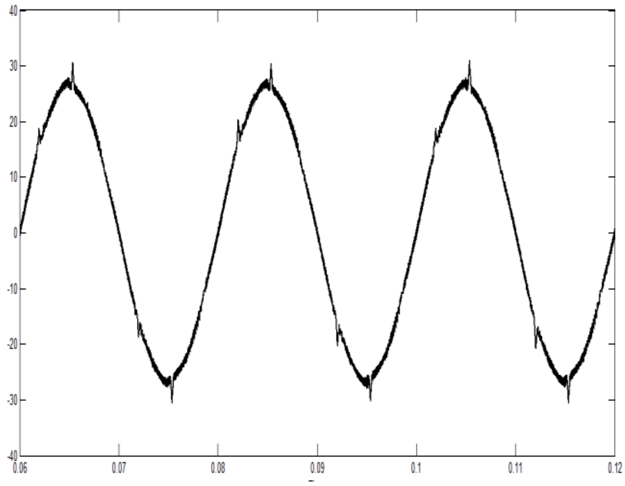

Figure 10(a). Source current for distorted supply voltage with Positive sequence detector.

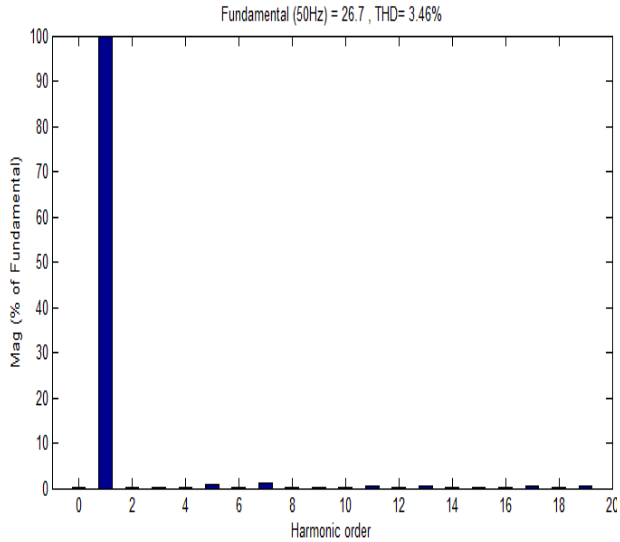

Figure 9(b). THD of Source current

VII. SUMMARY

Parameter	Sinusoidal voltage		Distorted Voltage	
	Without Shunt Active Filter	With Shunt Active Filter	Without positive sequence detector	With positive sequence detector
Active Power	13.05kw	13.41kw	13.10kw	13.20kw
Reactive Power	1104 VAR	-30 VAR	-40VAR	-30VAR
THD in source current	26.47%	3.33%	6.48%	3.46%

VIII. CONCLUSION

Simulation of shunt active filter for both sinusoidal and distorted supply voltage has been done. Simulation results shows that shunt active filter with positive sequence detector circuit gives effective compensation of harmonics and reactive power. Total harmonic distortion fulfill the IEEE 519 standard which required below 5%.

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Patel Pratikkumar T. is student of M. E. Electrical engineering (Power system), Government engineering college, Bhuj. He has received B.E. in Electrical engineering from saurashtra university in 2009. His research interest includes power system and Electrical machines

P. L. Kamani, has received B. E. in Electrical Engineering from Saurashtra University, Rajkot in 1999 and M. E. in Industrial Electronics from M. S. University, Baroda in 2003. He is currently Associate Professor, Electrical Engineering department in Government Engineering College, Bhuj. He has total teaching experience of 10 years.

A. L. Vaghamshi, has received B. E. in Electrical Engineering from Gujarat University in 2007 and M. E. in power system from Gujarat University in 2009. He is currently Assistant Professor, Electrical Engineering department in Government Engineering College, Bhuj.